PROC. ENTOMOL. SOC. WASH.
90(1), 1988, pp. 47–51

OCCURRENCE OF SELECTED FLOWER HEAD INSECTS OF *CENTAUREA SOLSTITIALIS* IN ITALY AND GREECE

Stephen L. Clement and Tiziana Mimmocchi

USDA, ARS, Biological Control of Weeds Laboratory—Europe, % American Embassy, Rome, Italy, APO New York 09794-0007; (SLC) USDA, ARS Plant Introduction Station, 59 Johnson Hall, Washington State University, Pullman, Washington 99164-6402; (TM) Via Baldo degli Ubaldi 59, 00167 Rome, Italy.

Abstract.—A 1984 survey was conducted in the south-Italian mainland and central Greece to locate sites where biocontrol specialists could collect insects of 6 promising biocontrol agents of yellow starthistle (YST), *Centaurea solstitialis* L., for use in host specificity tests. Four of these flower head insects were found: *Urophora quadrifasciata* and *Terellia* sp. (Diptera: Tephritidae) in Italy, and *Eustenopus hirtus* and *Larinus curtus* (Coleoptera: Curculionidae) in Greece. *Urophora jaculata* was the most abundant and ubiquitous species, but it is not a potential biocontrol agent because larvae will not develop in the heads of U.S. forms of YST. New and supplementary information on the distribution of several YST flower head insects and the extent to which they attack heads in Italy and Greece are also presented and discussed in relation to published information.

Centaurea solstitialis L. (yellow starthistle [YST]) is a Eurasian winter annual or biennial plant that has spread to the United States where it is a weed on over 3 million hectares in some western states (Maddox et al. 1985, Maddox and Mayfield 1985). Attempts to control YST biologically in the U.S. began in the 1960's when a flower head gall fly, *Urophora jaculata* Rondani (Diptera: Tephritidae), erroneously called *U. sirunaseva* (Hering) in some earlier references, was introduced from Italy (White and Clement 1987). Repeated efforts to establish this fly on U.S. forms of YST were unsuccessful. However, weed biocontrol workers discovered that a flower head weevil from Greece (*Bangasternus orientalis* (Cap.); Coleoptera: Curculionidae) will attack and complete its development on U.S. plants (Maddox and Sobhian 1987). This weevil, first released in western U.S. in 1985, is now established in California (Maddox et al. 1986).

We assumed that additional biological control agents would be needed to supplement the action of *B. orientalis* so in 1984 we surveyed YST in Italy and Greece to locate populations of promising agents, namely the tephritid flies *Chaetorellia hexachaeta* (Loew), *U. sirunaseva*, *U. quadrifasciata* (Meigen), and an undescribed *Terellia* species (= *T.* cf *virens* (Loew) in Sobhian and Zwölfer [1985]), and the curculionid beetles *Eustenopus hirtus* (Waltl) (= *E.* cf *abbreviatus* Faust in Sobhian and Zwölfer [1985]) and *Larinus curtus* Hochhut. We targeted these six flower head species for study because our preliminary work and unpublished reports at the USDA, ARS Biological Control of Weeds Laboratory—Europe (BCWLE), Rome, Italy, indicated they had restricted host ranges in southern Europe. More than one species may be confused under the name *quadrifasciata* (I. M. White, pers. comm.) and some populations of *C. hexachaeta* may be separate species

Table 1. Sites surveyed in Italy and Greece, collection dates, total number of flower heads of *Centaurea solstitialis* collected and percent damaged by insects at each site, 1984.

Sites Surveyed	Site No.	Collection Dates	No. Plants Sampled	No. Heads Collected	% of Heads Damaged
Italy					
5 km E S. Giovanni Rotondo, Promontorio del Gargano, Puglia Region (41°45′N, 15°55′E)	1	July 17 and Aug. 21	10[1]	454	37.89
9 km S S. Giovanni Rotondo	2	July 17 and Aug. 21	20[1]	320	13.75
12 km E S. Giovanni Rotondo	3	July 17 and Aug. 21	10[1]	273	24.54
15 km NW S. Paolo di Civitate, Puglia (41°40′N, 15°20′E)	4	July 17	52	155	14.02
Castel del Monte, Puglia (41°40′N, 16°15′E)	5	July 17 and Aug. 21	16[1]	649	14.19
10 km N Rome, Lazio Region (42°10′N, 12°15′E)	6	July 25, Aug. 14 and Sept. 7	10[1]	1627	18.19
Greece					
5.5 km W Agiokambos (39°45′N, 22°45′E)	1	Aug. 3	5	161	18.01
Xiniada (39°10′N, 22°20′E)	2	Aug. 3	5	179	50.28
ca. 6 km E Karpenissi (38°50′N, 22°50′E)	3	Aug. 4	5	105	41.90
Hounii (38°45′N, 21°30′E)	4	Aug. 4	2	44	65.91
ca. 2 km S Arta (39°10′N, 20°55′E)	5	Aug. 5	10	86	10.41
10 km N Igoumenitsa (39°30′N, 20°15′E)	6	Aug. 5	6	258	19.77

[1] Same plants were sampled each time.

(I. M. White, in press), but further taxonomic study is needed to clarify these possible species groups.

The objective was to locate sources of insects of the aforementioned species for use in host specificity tests and to provide new and supplementary information on the extent to which these and other species attack YST heads in southern Europe. Our approach was to record the occurrence of each flower head species on single host populations at several sites in the south-Italian mainland and central Greece. Information of this type is virtually nonexistent in the literature (Zwölfer 1965, Zwölfer et al. 1971, Sobhian and Zwölfer 1985) on YST flower head insects in Europe.

Methods

Samples were collected at twelve sites during the 1984 flowering season (Table 1). Seven of the sites were sampled once during July and August, but the literature (Sobhian and Zwölfer 1985) and our unpublished data indicate that the six species we were most concerned with can be found on YST during these two months. Therefore, we are reasonably certain that our one-time collections were sufficient to establish the presence or absence of these insects at each site. It was convenient to sample five Italian sites more than once because other studies were being conducted at or near these sites. Survey sites were roadside areas, embankments, and open fields (<3.5 ha) along roads. Each collection consisted of all heads in the flowering and seed formation stages (see Maddox 1981 for description of stages) from five or more randomly selected plants per site, except at one site where only two plants were available for sampling. At five Italian sites, the same plants were sampled two or

Table 2. Occurrence of flower head insects of *Centaurea solstitialis* at several sites in Italy and Greece, 1984.

Species	Relative Occurrence[1]											
	Italian Sites						Greek Sites					
	1	2	3	4	5	6	1	2	3	4	5	6
Diptera												
Tephritidae[2]												
Urophora jaculata Rondani	***	**	**	**	**	***	**	**	**	**		*
U. quadrifasciata (Mg.)				*		**						
Terellia sp.	*	*			*	*						
Acanthiophyllus helianthi (Rossi)					*	**		*	*		**	*
Chaetorellia sp. nr. *C. carthami* Stack.	**	*	**	**	*	**						
Coleoptera												
Curculionidae[3]												
Bangasternus orientalis (Capiomont)							P			P	P	P
Eustenopus hirtus (Waltl)							**	**				
Larinus curtus Hochhut										*		*
Bruchidae												
Bruchidius tuberculatus (Hochhut)[4]				*								
Anobiidae												
Lasioderma sp. nr. *haemorrhoidale* (Illiger)[5]						*						
Lepidoptera												
Cosmopterigidae												
Pyroderces argyrogrammos (Zeller)[6]												*

[1] *** Abundant (>30 specimens emerged). ** Low abundance (5–29 specimens emerged). * Very low abundance (1–4 specimens emerged). P = species present (see text for explanation).

[2] Identity of *A. helianthi* was checked by comparison with specimens identified by Dr. R. H. Foote, former Research Entomologist, Systematic Entomology Laboratory, IIBIII, USDA, Beltsville, Maryland. Other tephritids were identified by Dr. I. M. White, C.A.B. International Institute of Entomology, London, England.

[3] Identified by E. Colonnelli, Dipartimento di Biologia Animale e dell Uomo, Vaile dell Universita, Rome, Italy.

[4] Identified by Dr. M. L. Cox, C.A.B. International Institute of Entomology, London, England.

[5] Identified by Dr. R. Madge, C.A.B. International Institute of Entomology, London, England.

[6] Identified by Dr. R. W. Hodges, Research Entomologist, Systematic Entomology Laboratory, IIBIII, USDA.

three times (Table 1). Samples from each site were pooled to calculate the percentage of heads with insect-damaged seeds.

The relative occurrence of each species and the percentage of heads with damaged seeds and receptacle tissues was assessed for each site by rearing the insects and dissecting all of the heads in a laboratory at the BCWLE. A species was artibrarily rated as abundant, low in abundance, or very low in abundance according to the number of emerging adults (see Table 2). Reared insects were identified to species. Because less than 10% of the eggs of *B. orientalis* survive to the adult stage (Sobhian and Zwölfer 1985, Clement and Sobhian, unpub. data), we assumed that very few, if any, adults would be reared-out. Thus, we recorded the presence or absence of this weevil at each site by looking for its eggs, which are usually laid singly on leaflets near a flower bud (Bu 1–2 stages of Maddox 1981) and are covered by a characteristic black cap.

Results and Discussion

The percentage of heads with insect-damaged seeds varied from 13.75–37.89% (average of 20.43% of heads attacked) in Italy and 10.41–65.91% (average 34.38%) in Greece; less than 20% of the heads were damaged at 4 Italian and 3 Greek sites (Table 1). Species packing (no. of species) per site ranged from 2–6 (average 3.67) in Italy and 2–5 (average 3.0) in Greece (Table 2). In contrast, Sobhian and Zwölfer (1985) reported average levels of resource utilization (% of heads attacked) and species packing of 36.9% and "above" 4 species for Italy, and 77.3% and 9.5 species for Greece, but these higher levels were based on samples from the south-Italian mainland and Sicily, and northern Greece. The average levels reported above for central Greece are comparable to the ones Sobhian and Zwölfer (1985) reported for Yugoslavia, Bulgaria and Romania (35.6% and 3.4 species). Thus, the collective evidence suggests that predispersal seed predation by YST flower head insects is not markedly high in many areas of southern Europe, including Greece where Sobhian and Zwölfer (1985) and Zwölfer (1985) reported that average levels of resource utilization and species packing were significantly higher than they were in the western Mediterranean (Italy and France). High rates of parasitization of several species (Sobhian and Zwölfer 1985) might account for the fairly low levels of resource utilization in many areas.

In all, we found 11 species of seed predators to be associated with YST heads (Table 2). Three of these, *Acanthiophyllus helianthi* (Rossi) (Diptera: Tephritidae), *Lasioderma* sp. nr. *haemorrhoidale* (Illiger) (Coleoptera: Anobiidae) and *Pyroderces argyrogrammos* (Zeller) (Lepidoptera: Cosmopterigidae) use plants in several genera as hosts, and 8, *B. orientalis, E. hirtus, L. curtus* (Coleoptera: Curculionidae), *Terellia* sp., *U. quadrifasciata, U. jaculata* Rondani, *Chaetorellia* sp. nr. *carthami* Stack. (Diptera: Tephritidae), and *Bruchidius tuberculatus* (Hochhut) (Coleoptera: Bruchidae) appear to be restricted to the genus *Centaurea* in the field (Sobhian and Zwölfer 1985, Clement, unpub. data). *Urophora jaculata* was the most ubiquitous and abundant species, but this tephritid is not a candidate biocontrol agent because it will not develop in the heads of U.S. forms of YST (White and Clement 1987). *Chaetorellia* sp. nr. *carthami* was widespread in Italy; however, this species will form hybrids with *C. carthami* Stack., a pest of cultivated safflower, so its safety as a biocontrol agent has been questioned by biocontrol workers (Sobhian and Zwölfer 1985). A third stenophagous species (i.e. restricted to *Centaurea* spp.), *B. tuberculatus*, has been disqualified because adults were found in the heads of cultivated safflower, *Carthamus tinctorius* L., in northern Greece (Sobhian and Zwölfer 1985). Four of the 6 species that we set out to find were detected; *U. quadrifasciata* and *Terellia* sp. were represented in the guild of flower head insects in Italy while *E. hirtus* and *L. curtus* were detected in Greece. None of these 4 species were abundant at any site (Table 2).

The failure of this survey to detect *U. sirunaseva* and *C. hexachaeta* was unexpected because Sobhian and Zwölfer (1985) reported that both species occur throughout much of southern Europe. However, recent taxonomic studies (White and Clement 1987, White in press) have revealed a more restricted distribution for these tephritids. This new information on *U. sirunaseva* and *C. hexachaeta*, together with information from this survey and the literature on *E. hirtus* (Ter-Minasyan 1967, Fremuth 1982, Sobhian and Zwölfer 1985) and *L. curtus* (Zwölfer et al. 1971, Fremuth 1982, Sobhian and Zwölfer 1985) suggest that none of these 4 species are rare but the 2 weevil species are better able to exploit YST over a much wider geographical area than are the 2 tephritid species. The seemingly broad ecoclimatic tolerances of *E. hirtus* and *L. curtus* would improve their chances for establishment in the western U.S. where YST occurs in markedly different climatic and vegetational zones (Maddox 1981, Maddox et al. 1985, Maddox and Mayfield 1985, Roché et al. 1986).

In summary, this survey has enabled us to: pinpoint sites where biocontrol specialists might be able to collect insects of 4 potential agents for use in host-specificity tests; clarify the Palearctic distribution of several YST flower head insects, including 6 species that are promising biocontrol agents; and contribute towards a better understanding of the extent to which YST flower heads are attacked by insects in southern Europe.

Acknowledgments

We are grateful to the taxonomic specialists (listed in Table 2) who identified specimens, I. White, D. Maddox and an anonymous reviewer for comments on the manuscript, and S. Craig for typing the manuscript.

Literature Cited

Fremuth, J. 1982. Cleoninae aus der Turkei und den angrenzenden gebieten (Coleoptera: Curculionidae). Fragm. Entomol., Roma 16(2): 239–258.

Maddox, D. M. 1981. Introduction, phenology, and density of yellow starthistle in coastal, intercoastal, and central valley situations in California. Agric. Res. Serv. U.S. Dept. Agric. ARR-W-20, July, 33 pp.

Maddox, D. M., A. Mayfield, and N. H. Poritz. 1985. Distribution of yellow starthistle (*Centaurea solstitialis*) and Russian knapweed (*Centaurea repens*). Weed Science 33: 315–327.

Maddox, D. M. and A. Mayfield. 1985. Yellow starthistle infestations are on the increase. Calif. Agric. 39(11–12): 10–12.

Maddox, D. M. and R. Sobhian. 1987. Field experiment to determine host specificity and oviposition behavior of *Bangasternus orientalis* and *Bangasternus fausti* (Coleoptera: Curculionidae), biological control candidates for yellow starthistle and diffuse knapweed. Environ. Entomol. 16: 645–648.

Maddox, D. M., R. Sobhian, D. B. Joley, A. Mayfield, and D. Supkoff. 1986. New biocontrol agent introduced for yellow starthistle. Calif. Agric. 40(11–12): 4–5.

Roché, B. F., G. L. Piper, and C. J. Talbott. 1986. Knapweeds of Washington. Coop. Ext. Bull. 1393. Washington State Univ., Pullman, WA. 41 pp.

Sobhian, R. and H. Zwölfer. 1985. Phytophagous insect species associated with flower heads of yellow starthistle (*Centaurea solstitialis* L.). Z. Ang. Ent. 99: 301–321.

Ter-Minasyan, M. E. 1967. Zhuki-dolgonosiki podsemeistra Cleoninae fauny SSSR. Tsvetozhily i stebleedy (Triba Lixini). Nauka Publishers, Leningrad. 141 pp.

White, I. M. and S. L. Clement. 1987. Systematic notes on the *Urophora* Robineau-Desvoidy (Diptera: Tephritidae) species associated with *Centaurea solstitialis* L. (Asteraceae, Cardneae) and other Palearctic weeds adventive in North America. Proc. Entomol. Soc. Wash. 89: 571–580.

White, I. M. In press. Taxonomic problems in the genus *Chaetorellia* Hendel. *In* Cavalloro, R., ed., Proc. CEC-IOBC Int. Symp. on Fruit Flies of Economic Importance, 7–10 April 1987, Rome, Italy. Balkema, Rotterdam.

Zwölfer, H., K. E. Frick, and L. A. Andres. 1971. A study of the host plant relationships of European members of the genus *Larinus* (Col.: Curculionidae). Tech. Bull. Commonw. Inst. Biol. Control, No. 14, pp. 97–143.

Zwölfer, H. 1965. Preliminary list of phytophagous insects attacking wild Cynareae (Compositae) in Europe. Commonw. Inst. Biol. Contr. Tech. Bull., No. 6, pp. 81–154.

Zwölfer, H. 1985. Insects and thistle heads: Resource utilization and guild structure, pp. 407–416. *In* DelFosse, E. S., ed., Proc. VI Int. Symp. Biol. Contr. Weeds, 19–25 August 1984, Vancouver, Canada. Agric. Can.